X. Impacts to Flood Control Projects

A. Corps Designed Projects

1. Levee Performance

The record breaking high waters that persisted throughout the summer of 1993 significantly impacted the flood control levee structures in the Rock Island District. Plate 103 shows the various levee district boundaries. Many of the Corps projects had the opportunity to be tested for the conditions for which they were designed. During the flood fighting effort, geotechnical personnel observed many miles of Mississippi River levees while the flood was occurring.

Boils were observed at nearly all of the sand levee projects. They occurred at the berm toes, inside curves, and very often at groves of trees. In some instances, vehicular traffic on levees aggravated the formation of the boils. To alleviate the problem, the boils were ringed with sandbags. Due to the saturated soils in the levees, foundations and berms, some of the ringed boils actually moved or created sinkholes.

Seepage initiated erosion was a common problem on the land side of nearly all sand levees. This resulted from the bulldozers pushing up material to raise the height of the levee, effectively removing the through seepage control mechanism for the quantity of water seeping through the sand levees. The loss of landside toe material, the associated pushup and the vehicle tracks that ran perpendicular to the levee were factors that contributed to the erosion. In some instances the erosion had cut halfway up the slope and reached depths of 18 inches. The method used to control erosion was bulldozer back blading and/or bulldozer railroad rail/I-beam dragging and application of straw, burlap, snow fences, sandbags, or pea gravel. The most widespread method used was the application of straw.

Sinkholes became a problem late in the flooding. At Sny Island Levee and Drainage District Reach 1, sand levees experienced several sinkholes on berms and landside levee toes and slopes. The sinkholes appeared to be interconnected with adjacent boils. The adjacent boils were typically discharging a significant clay component indicating a relatively shallow underseepage path. This loss of material at shallow depth of some boils explains the relatively rapid formation of sinkholes nearby as opposed to other boils discharging deeper sands which were less likely to produce sinkholes. Most sinkholes developed on berms at distances of 10 to 75 feet riverward of berm toe boils. Sinkholes first appeared as 5 foot diameter holes ranging in depth between 1 and 8 feet deep. They were treated by a slow feed application of clean gravel or sand when possible, and usually stabilized within six hours. The worst cases encountered involved sinkhole boil systems that actually moved closer to the levee, or up the levee slope after treatment. The attempt to balance the discharge of water and soil movement from interconnected boils and sinkholes caused the movement of sinkholes until a balance was achieved.

Sloughing occurred in several of the drainage district sand levees. The material that sloughed usually contained a significant portion of silt and or clay. The sloughing occurred as the relatively rapid flow-through sand blew out the less pervious layer. This surface layer was typically about 2 feet thick. The various methods that were used to control sloughing included straw, snow fence, sandbag systems, sandbag toes, drains and lumber reinforcing.

Pushed up section sloughing was also a major problem in many instances. This was the result of numerous factors, e.g., heavy saturation of sand layer, water seeping over the old clay cores, relatively loose density of the pushed-up material, and seepage along the old levee pushed up section interface. Repairs to these soft/flowing/sloughing areas usually included hand-shoveled sand and application of straw, snowfence, and sandbags.

Flashboard systems were used extensively on reaches of clay levees at Canton, Mo., Green Bay D.D., South River D.D., Indian Grave D.D., and Sny Island D.D. 1. The systems were typically braced on the landside by 2x4 inch lumber driven approximately 2 feet into the levee crest and spaced on 10 foot centers. Plastic was keyed into the crest on the riverside of the flashboards to a depth of about 6 inches, and then wrapped over the boards and secured with sandbags. The landside of the flashboard systems were typically reinforced with sandbags. Water was observed at heights of more than 2 feet on the South River D.D. flashboard system. All flashboard systems performed well with only nominal seepage occurring between the boards and the levee crest.

Many of the levee districts experienced inundation as a result of overtopping or breaks in the levees. Table 27 summarizes when the levees were overtopped, how many acres were protected and whether portions of the levee broke.

Table 27
Impacts to Federal Levees

Date	**Levee**	**Acres Protected**	**Impact to Levee**
	Mississippi River		
7/8/93	DesMoines Mississippi D.D (Agricultural/Urban)	11,000	Overtop
7/8/93	Gregory D.D. (Agricultural)	8,000	Overtop
7/9/93	Hunt-Lima Lake D.D (Agricultural/Urban)	28,000	Overtop
7/9/93	Marion CoD.D.(Agricultural)	4,000	Overtop
7/11/93	Green Bay D.D. (Agricultural/Urban)	13,500	Overtop
7/12/93	Indian Grave Lower Section (Agricultural/Urban)	8,000	Overtop
7/13/93	South River D.D. (Agricultural /Urban)	10,000	Overtop
7/13/93	Indian Grave Upper Section (Agricultural/Urban)	10,000	Overtop
7/16/93	Fabius River D.D. (Agricultural/Urban)	14,300	Overtop
7/25/93	Sny Island Upper Section (Agricultural/Urban)	44,200	Overtop
NA	Henderson County D.D. 1 (Agricultural)	6,160	Erosion
NA	Henderson County D.D. 2 (Agricultural)	8,000	Erosion
NA	South Quincy D.&L.(Urban)	5,800	Erosion
NA	Iowa River-Flint Creek L.&D.D. No. 16 (Agricultural/Urban)	48,000	Erosion
NA	Penny Slough Levee & D.D. Rock River/Agricultural	10,000	Erosion

2. Structural Performance

All of the Rock Island District Local Flood Protection Projects were inspected to evaluate the impact of the flooding to the structures. Table 28 shows the projects that were inspected and briefly summarizes their performance. In general, all of the projects provided the flood protection for which they were designed. Some minor problems occurred to the structures and are summarized in Table 28. Details of the inspections are beyond the scope of this report.

Table 28
Performance of Local Flood Protection Projects

Local Flood Protection	Performance	Remarks
Bettendorf, IA	as designed	- Deteriorating expansion joints of gatewalls -Damaged headwall - Problem with closure structure
Burlington,IA	as designed	- slight tilt of floodwall
Canton, MO	as designed	- Seepage damage / pump station & treatment plant -Erosion
Clinton,IA	as designed	- Minor spalling on floodwall - Riprap obstructing pumping station outlet
Des Moines, IA	as designed	-Erosion -Replace RR sandbag closure
Dubuque,IA	as designed	- Monolith settled -Floodwall needs riprap -Problem with gatewall -Problem with closure structure
East Moline, IL	as designed	-Riprap washed out Debris
Evansdale, IA	as designed	-Damage gatewell C
Fulton,IL	as designed	-Riprap washed out - Debris
Galena, IL	as designed	-Problem with j seals
Hannibal, MO	as designed	-Crack in valvewell
Marengo, IA	as designed	
Marshalltown, IA	as designed	-Some siltation
Milan, IL	as designed	- Some siltation - Pumping station maintenance
Muscatine, IA	as designed	- Siltation - Problem with closure structures
Muscatine Island,IA	as designed	-Some siltation -Some scour
Rock Island, IL	as designed	-Siltation - Riprap blocking outflow - Problem with gatewall -Leakage along closure structures
Sabula, IA	as designed	- Broken flapgate - Problem with closure structure - Bank erosion
Van Meter, IA	as designed	- Wingwall failed
Waterloo, IA	as designed	-Problem with floodwall -Damage to gatewell K-5

3. Dam Performance

In general, the three Rock Island District dams performed as designed, and the details of the operation are provided in Sections V and VI. The impact the Flood of 1993 had on each of the reservoir projects is discussed below.

The unprecedented reservoir pool levels and release rates that occurred during the spring and summer of 1993 warranted personnel from the Geotechnical Branch of the Rock Island District to staff the Red Rock and Saylorville Lake facilities full time during July. The inspection teams evaluated the main embankments, outlet and/or spillway works, grout gallery and other features on a daily basis.

Saylorville Dam exhibited some minor problems as a result of the excessive rain and saturated soils. A small slump on the downstream slope near the left abutment and a small seep on the downstream slope near the slump occurred at the dam. The slumps were approximately 50 and 100 feet in width, with the larger slump having a vertical scarp face of 12 to 18 inches and the smaller one, 6 to 8 inches. These vertical displacements increased over time to the point the largest vertical distance was about 4 feet. The downslope toe bulge was 15 to 20 feet down the slope. These were closely monitored to insure no changes occurred. Geotechnical engineers for NCR, NCD and consultants, hired by the State of Iowa, investigated and all came to the same conclusion that the slump was superficial in nature and was a result of saturated soils on the downstream surface of the dam and was therefore not due to through seepage. In addition to the minor problem to the dam, the spillway channel experienced erosion in the bedrock channel and the riprap at the end of the wingwall due to the extended period of high flow down the emergency spillway channel. Slides along the channel banks created a potential hazard to several homes located at the top of the slope. Another minor problem at Saylorville was that the pump station at the Barrier Dam had a difficult time keeping the pool on the protected side down to prevent Polk City facilities from being flooded. Three submersible pumps with a combined capacity of 12,000 gpm were installed and used for 17 days to lower the Barrier Dam pool.

The Red Rock Dam had no major problems that affected the integrity of the structure. During operation (as described in Section V, Des Moines River Basin, E. Reservoir Regulation Red Rock Reservoir), the gate settings had to be adjusted because 5 of the 40 cables that operated the gates broke.

The Coralville Dam was monitored from the Rock Island District Office and inspections were made on a one to two day frequency. There were no problems of significance noted at the Coralville Reservoir.

B. Non-Corps Designed Projects

A complete evaluation of the impacts to all non-federal flood control projects resulting from the high water is beyond the scope of this report. The non-federal drainage districts that requested and received assistance in the rehabilitation of their levees are summarized in Table 29.

Table 29
Impacts to Non-Federal Levees

Date	Levee	Acres Protected	Impact to Levee
	Mississippi River		
7/1/93	Mississippi-Fox D.D.2 (Agricultural)	8,700	Overtop
7/3/93	Green Island (Agricultural)	4,500	Overtop
	Iowa River		
7/7/93	Louisa County Levee D. 11 (Agricultural)	3,200	Overtop
7/7/93	Louisa County Levee D. 14 (Agricultural)	850	Overtop
7/7/93	Louisa County Levee D. 8 (Agricultural)	2,550	Overtop
	Skunk River		
7/7/93	Union Township Levee (Agricultural)	900	Overtop
	Spoon River		
7/25/93	Zempel Mutual D.D. (Agricultural)	1,100	Overtop
7/25/93	Spoon River Project 1 (Agricultural)	1,907	Overtop
7/25/93	Lower Pleasant Valley Levee & D.D. (Agricultural)	930	Overtop
7/27/93	Spoon River Ranch and Roddis D. & L. District (Agricultural)	500	Overtop